On the Choice and Use

OF

Photographic Lenses.

BY

J. H. DALLMEYER.

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PORTRAIT LENSES.

SUCCESS IN PORTRAITURE will always depend, in a great measure, upon the *right choice* and the *proper use* of the lens. A few hints on these two points may prove of service to the photographer.

Portrait lenses are either more or less rapid in action as their diameters are larger or smaller, or as their focal lengths are shorter or longer. The diameter of a lens here always implies its *actual* working aperture, and the focal length, its *equivalent* focal length. Directions for ascertaining these are given in the appendix.

The focal length of a lens regulates the *size* of the picture, and the diameter expresses its *speed* or rapidity of action. Having fixed upon the size of picture required to be taken, the next thing to be determined is the most suitable focal length of the lens. This, however, involves the

prior determination of the *distance* at which to place the subject; for, as every photographer knows, the placing of the lens nearer to the subject increases the size of the picture, and *vice versâ*. The question then arises,—What is the proper distance at which to place the subject from the lens? In answer it may be safely asserted, that it should, as a rule, be not less than 12 feet, nor perhaps more than 24 feet. For if less than this, the resulting picture will generally be defective both in definition and perspective, because the lens producing it will be of too short a focus; and if the distance is greater, the resulting picture will probably be deficient in relief or roundness. This, because the atmosphere in our towns is seldom quite clear from fog or haze,* and the greater the distance between the lens and subject, the more obviously will this haze be reproduced in the picture.

A medium distance, therefore, of from 16 to 20 feet, should be chosen. Card portraits are generally taken with lenses of such focal lengths as to require this distance, and to this circumstance may be attributed the generally pleasing appearance of these portraits, as compared to the old quarter plate pictures, which were mostly taken with lenses of much shorter focal lengths.

* The writer refers, of course, to towns in England.

For a distance, then, of from 16 to 20 feet between the lens and subject, the *equivalent* focal length (not the back focus) of the lens, for a given sized plate, should be about *twice* that of the largest side; that is, for a $4\frac{1}{4} \times 3\frac{1}{4}$ plate, the card size, the focal length should be $4\frac{1}{4} \times 2$, or equal to $8\frac{1}{2}$ inches, *i. e.*, No. 2 B Lens; for a 6×5 plate, the cabinet size, 6×2, or equal to 12 inches, *i. e.*, 3 B, 2 A, or better still, 3 A Lens; for a 10×8 plate 10×2, equal to 20 inches, *i. e.*, 4 A Lens, and so on.

In confirmation of this, I may mention that the much admired 10×8 pictures of M. Adam-Salomon are taken with a 20 inch focal length lens.

The distance between the lens and subject here given requires a studio of at least 30 feet in length; and photographers who have not this space are compelled to use lenses of shorter focus, such as the 1 B [long] or 1 B for cards, and the 1 A for cabinets; but they labor under disadvantages, as regards instrumental aid, which no amount of skill can possibly compensate.

Having determined the *focal length* of the lens for a *given sized plate*, the next thing requiring consideration is its *diameter*, or its rapidity of action. As a matter of course, every photographer wishes to possess a quick-acting lens, and not only this, but flatness of field, and great

"depth" of focus or definition, forgetting all the while that these qualities are almost diametrically opposed to each other; for rapidity can only be had at a corresponding sacrifice of flatness of field and depth of definition. Thus, of two lenses of the same focal length, and both perfectly corrected for spherical aberration, the one of 2 inches will have twice the depth of another of 4 inches in diameter; whilst the latter, in turn, is four times quicker in action than the former.

Again, of two lenses of the same rapidity (*i. e.*, having the same ratio of aperture to focal length), the one double the focal length of the other will only have one quarter its "depth." Thus, for example, a card lens of 9 inches focal length and 2¾ in. aperture, producing a card picture at 20 feet distance, will sufficiently define accessories 12 inches in front and 12 inches behind the figure, or the point focussed upon, or will have a depth of 2 feet; whereas, another lens of double the above dimensions, *i. e.*, of 18 in. focus and 5½ ins. aperture, and worked at the *same distance*, will only have a depth of 6 ins., viz., 3 in. before and 3 in. behind the point focussed upon. This sufficiently explains that really quick acting lenses only produce satisfactory results when used for the smaller sized plates; but that they are useful, when so restricted is suf-

ficiently evidenced by the charming instantaneous portraits of children by Mr. Faulkner, Mr. H. C. Heath, and others, taken with No. 2 C—perhaps the quickest acting lens extant.

For standing figures this lens requires stopping down, as explained in my Catalogue.

Hence the quick acting, or B Lenses, are only made for plates up to $8\frac{1}{2} \times 6\frac{1}{2}$. For larger pictures slower working lenses, capable of adjustment for diffusion of focus, are the only means for securing the requisite amount of depth of focus.

It may be stated here that for every-day work, for whole plate Portraits and beyond, perhaps the Patent A Lenses are the most suitable. They are nearly twice as rapid in action as the D Lenses; of great importance considered from a commercial point of view; for long exposure very often occasions a failure. Hence nearly all the first artists, as for instance Messrs. Blanchard, Briggs, Heath, Mayall, Mayland, Robinson, Slingsby, Wane, and others, constantly use these lenses for the ordinary demand of portraits; but for their extra size pictures, as for instance for those recently exhibited, the first-named artist uses No. 5 or 6 D.; Mr. Slingsby a No. 7 D.; and Mr. Crawshay, for the largest portraits, perhaps, ever taken direct, a No.

8 D. Col. Stuart Wortley's large portraits were taken with a 22 $\times$ 20 Rapid Rectilinear Lens.

Thus much respecting the right choice of the lens; and now a few words regarding the proper use of it.

The lens, when attached to the camera, should be placed upon a *firm* stand, capable of adjustment as to height etc.; the cap should fit the lens loosely, so that its removal does not occasion tremor, or shaking of the camera. Cap the lens, and, protected by the focussing-cloth, carefully examine the interior of the camera to insure a perfect dark chamber. No bright object, such as the unblackened head of a screw, or a bright brass spring on the shutter, should be tolerated anywhere. The wood of the interior of the camera, also, should be coated with a *dead*, and not a shining, black varnish; and, better still, a number of diaphragms, according to the length of the camera, should be introduced, allowing the full cone, or pencil of light, proceeding from the lens, to fall upon the prepared plate uninterruptedly, cutting off all reflections from the sides of the camera. The larger the diameter, or the more rapid the lens, the greater the importance of the above remarks.

Always carry the slide containing the prepared plate under a focussing-cloth to the camera, and let this cloth remain on it when drawing up the shutter.

Now proceed to test the camera as to *register*. At a convenient distance place a sheet of newspaper or other clear print; carefully focus for this on the screen. (A focussing glass, such as a Ramsden eye-piece of about 1 or $1\frac{1}{2}$ inch focus, adjusted upon the greyed surface of the ground glass, should always be used for this purpose.) This done, remove the screen, and replace it by the collodion slide; but, instead of introducing the sensitized plate, put into the slide a piece of ground glass, ascertained to be perfectly flat. Now observe whether the image appears as sharp on this as it was previously on the screen; if so, the camera is correct, or what is technically called in "register;" if the image is not sharp, the position of the ground glass requires to be altered until it is so.

The common practice of *measuring* by means of a rule the distance between the camera front and screen, and then between the front and prepared plate in the collodion slide, is quite inadequate to insure the necessary accuracy, especially for quick-acting lenses.

Care should also be used in the selection of the glass for the negatives, for it will be found that, even of the patent plate, the percentage of *really* flat glasses is but small, more especially among the larger sizes.

Another source of error frequently exists in a too pow-

erful *spring* on the door of the dark slide. This, when too strong, causes a bending of the prepared plate in the centre, and, unfortunately, this bending is just in the opposite direction to that required by the slight curvature of image as produced by all lenses. Thick plates are, of course, less liable to bend than thin ones; but to be quite rid of this possible source of error, remove the *one* strong spring from the centre of the shutter, and replace it by *two* weaker ones, made to press equally on the two sides of the plate. Lenses are sometimes blamed for non-coincidence of foci, when the fault is really an imperfect camera, or defective glass plates; it is hoped, however, that a little attention to the above will at once satisfactorily determine this point.

As regards the best position of the camera, a few hints may be of advantage, especially when it is required to take a standing figure; for no lens gives a perfectly flat field; and hence the placing of the camera requires great care, in order as much as possible to favor the action of the lens.

For a card portrait, using No. 2 B Lens, distance of subject 18 feet, the camera being without a swing back, arrange as follows:

Height of centre of lens from the floor, about 4 feet 10 inches; rising front of camera elevated ½ inch; let the

image occupy the centre of the plate—*i. e.*, the head and feet equidistant from bottom and top of screen. To effect this, the camera requires tilting forward slightly. (Tilting the camera forward is an advantage, for it produces a more natural view of the face, and is preferable to its being placed lower and level, which latter position implies a looking *up* into the face, and produces neither a natural nor pleasing picture.) The image occupying the centre of the plate, proceed to focus for the eye, and then for the chest, or for some prominent object on the chest, as a watch chain for instance; now halve, as it were, the focus between this and the eye, when it will be found that the resulting picture will be evenly defined throughout its entire length.

The above is the actual *modus operandi* of one of our ablest portraitists, to whom I am indebted for the particulars.

For the cabinet portrait, standing figure, using No. 3 B, 2 A, or 3 A lens nearly the same conditions obtain; and hence the camera should be placed in the same position.

Photographers *compelled*, on account of insufficient length of studio, to use shorter focus lenses than the above —viz., a No. 1 B or 1 B long, for cards, and No. 1 A, for

cabinets, should use the utmost care in adjusting the position of camera, for the use of shorter focus lenses implies a larger angle of definition. The above should be modified thus: Height of centre of lens from floor, 4 feet 8 inches; rising front, elevated ⅛ to 3-16ths inch; the rest as before.

A sitting figure requires the camera to be placed at a somewhat lower level, and here a swing-back to the camera is of great advantage. Indeed, portraits beyond the half-plate size should never be attempted without this adjunct; for, as stated already, the longer focus lenses are much more sensitive to any difference of distance than are the shorter focus ones, and in a sitting figure the feet are often as much as 24 inches in advance of the face. This occasions nearly ¼ of an inch of difference in the focus of a 20 inch lens. Hence, without a swing-back, allowing the top of screen or slide to be inclined outwards that distance, definition of the feet and legs simultaneously with the face is almost impossible.

In placing the accessories of a portrait, or in disposing the positions of a group of persons, regard should always be had to accommodate as much as possible the curvature of field produced by the lens; and this is accomplished by arranging the group or accessories in approximation to a curve. That is, objects at the sides should be brought

nearer to the lens than those occupying the centre; the image then falls on a *plane*, and this is what is required. The amount of curvature of field varies in different lenses, and hence definite rules for placing the objects composing a picture to suit this curvature cannot be given, but one or two trials will at once determine this question.

One other point remains to be noticed; it is this. A photographer accustomed to work with a short focus lens, and exchanging this for another of longer focus for the same sized plate, often complains of a want of brilliancy or roundness in his pictures. Now, in almost every instance, this is simply a question, not of lens, but of *lighting*, for a little consideration will make it apparent that the direction and amount of light suitable for a subject at a distance of 12 feet, requires considerable modification, when the distance is increased to 20 feet.

Then as to the time of exposure required by a lens—a question so frequently asked, but one which involves so many elements, viz., aperture of lens, lighting, chemicals, etc., that it is impossible to give a definite answer. A correct reply can only be given *relatively*; that is, if the time of exposure for a certain class of lens is known, then another kind of lens will require so much more or less, as the case may be, according to its construction. This information

is to be found in my catalogue, where the lenses are classified according to their respective rapidities. If nothing relatively is known, then one or two experiments with the full aperture, of the lens in question, is at once the readiest way to determine the point; and when ascertained for the full opening, the rule for finding it for any smaller-sized stops is given in the catalogue.

VIEW LENSES.

THE right choice among the many existing forms of view lenses requires the determination of the following points:

1st. The size of the picture.

2nd. The angle of view, or amount of subject to be included in it.

3rd. The kind of picture, whether landscape, or architectural, or both.

As regards the first point, viz., "the size of picture," the professional photographer needs no information—he being guided by commercial considerations—but a few remarks addressed to the amateur on this head may be of service.

The beginner will find a small sized plate, such as a $7\frac{1}{4} \times 4\frac{1}{2}$ up to 10×8 in., quite sufficient, being convenient for practice, and enough for producing artistic effects. The former of these sizes has the advantage of being adapted alike for a stereoscopic, or for one single, picture.

In recommending the smaller sized plates, it may be well to remind the amateur that not only do the difficulties of manipulation greatly increase with any increased dimensions of plate, but that the quantities, weight, bulk, etc., of all the other necessary appliances become augmented also, and this in the proportion of more than the *square* for every increase in size of plate.

Secondly, "The angle of view" to be included in the picture. This depends upon the relation of its size to the focal length of the lens; that is, the shorter the focus the larger the angle, and *vice versâ*. The base line, or the longest side of the picture, is the measure of the angle included in it. One of the principal and rightful claims of photography is its perfect truthfulness of delineation; and yet, how frequently do we meet with pictures representing well-known objects or scenes, which at first sight are not even recognized! This fact has been observed more frequently of late, since the introduction of the wide-angle, or short-focus lenses. The cause of these *apparently* dis-

torted views really turns upon the amount of angle included in them, and hence there arises the question, What is the proper amount of subject, or angle, to be included in a picture?

The reply to this necessarily involves a consideration of the laws of perspective—a subject well worthy the attention of every photographer.

The following two propositions are sufficient for my present purpose, viz.: That the human eye itself is a miniature photographic camera, inasmuch as the several rays proceeding from objects, upon entering the eye, are refracted by its lens, and thence proceed to form a most perfect image or picture on the smooth screen of nerve called the *retina*; and that it is by this picture that the mind is enabled to judge of the dimensions, brightness, color, etc., of external objects. The angular extent of the picture formed upon the retina certainly does not exceed 60°, without some movement of the eye or head. Hence, for a photograph to convey to the mind a correct idea of the objects represented, it should, when viewed at the normal distance of from 12 to 15 inches, excite the same impressions. Now the distance at which a picture is generally viewed will be found to be about equal to its base, or longest side; or, in other words, the angle it subtends for

vision will be from 50° to 60°. This angle, therefore, should not be exceeded, for if more is included in the picture, the perspective will appear exaggerated, *i. e.*, objects in the foreground will be too large, and the distance become dwarfed.

To render it obvious that distortion of this nature is really no fault of the lens, when such pictures are viewed at a distance equal to the focus of the lens with which they are taken, all apparent distortion at once vanishes. This rule holds good in all cases, *i. e.*, every picture should be viewed at a distance equal to the focal length of the lens with which it is taken. Thus a 12 $\times$ 10 picture taken with a 7 in. focus wide angle Rectilinear Lens should be looked at, not at 12 or 15 inches, but at 7 inches distance from the eye.

From the above it is obvious that the only legitimate use of wide angle lenses is landscape photography; or, in other words, for that class of subjects in which absolute truth is subservient to beauty; but for architecture, and the like, such lenses should be used only in case of necessity—*i. e.*, when the situation is so *confined* as to preclude the use of a longer focus lens.

As regards the choice of a *landscape lens*, all the most eminent landscape photographers are unanimous in recom-

mending the "single combination" for simple landscapes, for the obvious reason that this lens, having but *two* reflecting surfaces, the rest being cemented, produces the most brilliant pictures; and, on account of its form, it has more depth of focus than a double combination lens. Further, the wide angle single combination landscape lens produces an evenly defined picture with a comparatively large stop or aperture. Hence, it is more rapid in action than the wide angle double combination lens, which it surpasses, moreover, in equality of illumination throughout the entire extent of the picture.

The only drawback to this form of lens is a slight amount of perceptible distortion when used for objects bounded by straight lines, such as architecture, where the marginal lines will be slightly curved. Hence, to avoid this, in a landscape with buildings, the latter should not be made to occupy the extreme margins of the picture.

Among the several kinds of single combination view lenses extant, other things being equal, the *smaller* its diameter, the better the lens.

As regards focal length, it has already been stated this should not be less than the base line of the picture; that is, for a 10 × 8 inch plate, a 10 inch focal length lens, rather longer than shorter, should be chosen. The profession-

al photographer desiring the best possible results must necessarily be provided with two or three lenses of different focal lengths for the same size of plate, so as to *suit* his lens to his *subject;* and this is really the practice of all our best photographers. Thus I may mention, that for Mr. G. W. Wilson, of Aberdeen, I made as many as five pairs of different lenses for his stereoscopic pictures, viz., three pairs of quick-acting single combination landscape lenses, of 4½, 6, and 8 inch focus respectively, and two pairs of wide angle Rectilinears of 3 and 4 inch focus. Mr. England uses similar lenses for his stereoscopic pictures; and for his well known 9 × 7 Swiss views he employs as many as *five* lenses, as occasion requires, *i. e.*, from 5¼ up to 10 or 15 inch focus. Mr. F. Good and others adopt the same practice.

For *architecture*, a rectilinear lens must, of course, be chosen, and for general use, one of moderate angle is to be preferred.

The Rapid Rectilinear is the best lens for that purpose, as it is free from distortion and flare, and works with a larger opening than any other kind of double lens. It is invaluable, therefore, for dark interiors, instantaneous effects, etc. Mr. Bedford has produced the most charming pictures with this lens, both of interiors and landscapes with buildings.

For *special* purposes, as for objects in confined situations, the wide angle Rectilinear lens becomes indispensable; but here it may be observed, for the reasons already given, that it should be used only in cases of necessity. More than ordinary care, moreover, is requisite in the adjustment of the camera when wide angle lenses are used. The camera should always be placed perfectly *level*, and, if required, the rising front should be used; but on no account should the camera be tilted, for, in that case, perpendicular lines of objects will no longer appear perpendicular in the picture. If, however, the camera must be tilted, then a swing-back becomes indispensable, in order to restore parallelism between the object and the screen, or collodion slide—always a necessary condition for the production of a picture free from distortion. Observe, it is the better plan not to *tilt* the camera, but, if more is required in the picture, to raise the camera-front or to get on higher ground, if practicable. Of double combination lenses, that one is always to be preferred which, with the *smallest* diameter of lenses, really works with the largest aperture or stop, and covers the widest angle. [See my paper "On the Cause of the Central Spot or Flare" in the *Photographic Journal*, June 15th, 1867.]

If a lens is required for *general purposes*, as for land-

scapes, architecture, instantaneous views, groups and portraits in the open air, then a double combination lens must be chosen; and for *out-door* work of this kind, I have no hesitation in stating that the Rapid Rectilinear is the best lens an amateur, or even a professional, photographer could fix upon.

All the instantaneous views by Mr. Robinson, Col. Stuart Wortley, and others, were taken with the Rapid Rectilinear lens; and the latter gentleman has even succeeded in producing his large portrait studies with the same instrument. But for portraits in *the studio* it is scarcely sufficiently rapid in action, and if it be the aim to combine this and landscape photography, etc., in one and the same instrument, then a D Patent Portrait Lens will probably best fulfill the several requirements.

For copying purposes, the Rapid Rectilinear Lens is without a rival. It has already been supplied to all the Government topographical establishments in Europe, India, and Australia. The two combinations composing this lens being perfectly *identical*, it is alike suitable for copying of equal size, or for reducing or enlarging.

One or two remarks about the proper use of a view lens, when the choice has been made.

In the selection of a view, always aim as much as pos-

sible to favor the natural curvature of field as produced by the lens, *i. e.*, if possible let the side objects be nearest to, and the centre ones farthest away, from the camera. When photographing a flat object, as a block of buildings, or when copying a map or plan, focus for a point one-third from the centre, and the resulting picture will be approximately equal in definition throughout.

Always work with the largest possible aperture or stop, if you wish to secure relief and atmosphere in your picture. Proceed as follows: Focus for *the* object, *i. e.*, that which is to constitute the point of *interest* in the picture, and which is generally near in the foreground; do this with a medium stop; when done, look to the distance and other objects in the picture, and only reduce the aperture just so much as will prevent these appearing foggy. But do not aim at equal sharpness everywhere, if you wish to produce *a picture*. For what artist would think of painting his background or accessories as sharp in outline as the *subject* of his picture? And who ever saw the distance perfectly sharp in nature when the eye is adjusted upon some object near in the foreground? Photography is claiming higher ground than the old standard of excellence, viz., *sharpness* everywhere; and those who aim at *artistic photography* may find the above hints of some service.

As regards the best kind of camera suitable for view lenses, that with the bellows body is the most convenient being portable, and, when well made, answering every purpose. Among these, perhaps, the *square* bellows body camera is preferable to that of the *conical*, or Kinnear form, inasmuch as the former can be used for lenses of very short focus, whereas the latter, when used for such lenses, frequently intercepts a portion of the cone of rays, and spoils the picture.

For directions of testing the camera, etc., see remarks on this subject under the heading "Portrait Lenses."

APPENDIX.

To find the *angle of view*, or the amount of subject included in a picture, ascertain the equivalent focus of the lens, and measure the base line of the picture. Upon a sheet of paper draw a line of the same length as the latter, bisect it, and let fall a perpendicular exactly equal in length to the equivalent focus of the lens; join the extremity of bisected line and perpendicular by another line; now apply a protractor, and measure the angle included between these two lines, and the angle read off, multiplied

by two, is the angle included in the picture. Or, with the data known as above, and a table of natural sines and tangents at hand, divide half the base line of the picture by the equvialent focus of the lens; find in the tables under the heading "tangents" the same ciphers as the above quotient, and the corresponding angle, multiplied by two, is the angle included in the picture.

The following particulars may be of service:

If the base line, or the longest side of the picture, is equal to the equivalent focus of the lens, the angle included is 53°; if the base line measures $1\frac{1}{4}$ the equivalent focus, the angle is 64°; if $1\frac{1}{2}$ it is 74°; if $1\frac{3}{4}$ it is 82°; if twice it is 90°.

Depth of focus, or depth of definition, is dependent upon the aperture and the focal length of the lens. It increases in the same ratio as the diameter of the opening or aperture is reduced, and it diminishes as the square for any increase in the size of picture, or the focal length of lens. Hence, the shorter the focal length, other things being equal, the greater the "depth," or the nearer may be an object in the foreground; beyond which everything else will be in practically good focus.

The *rapidity* of a lens depends upon the relation or the ratio of aperture to the equivalent focus. To ascertain

this, divide the *equivalent focus* by the diameter of the actual *working aperture* of the lens in question; and note down the quotient as the denominator of a fraction with 1, or unity, for the numerator. Thus, to find the ratio of a lens of 2 inches diameter and 6 inches focus, divide the focus by the aperture, or 6 divided by 2 equals 3; *i. e.*, $\frac{1}{3}$ is the intensity ratio. Another lens, of 4 inches diameter and 24 inches focus, has 1-6 for its intensity ratio; and this ratio once ascertained, it only remains to multiply each denominator by itself to find their comparative rapidities. As above, the ratio of the 2 in. lens is $\frac{1}{3}$, or 3×3 equals 9; the ratio of the 4 in. lens is 1-6, or 6×6 equals 36: therefore, if the 2 in. lens requires 9 seconds exposure, the 4 in. lens necessitates 36 seconds; or, in other words, the 2 in. lens is four times quicker acting than the 4 in.

It must be observed, however, that in order to find the real *intensity ratio*, the diameter of the actual working aperture must be ascertained. This is easily accomplished in the case of single lenses worked with front stops, or for double combination lenses used with the full opening, these merely requiring the application of a pair of compasses or rule; but when double or triple-combination lenses are used, with stops inserted *between* the combina-

tions, it is somewhat more troublesome; for it is obvious that in this case the diameter of the stop employed is not the measure of the actual pencil of light transmitted by the front combination. To ascertain this, focus for a distant object, remove the focussing screen and replace it by the collodion slide, having previously inserted a piece of cardboard in place of the prepared plate. Make a small round hole in the centre of the cardboard with a piercer, and now remove to a darkened room; apply a candle close to the hole, and observe the illuminated patch visible upon the front combination; the diameter of this circle, carefully measured, is the actual working aperture of the lens in question for the particular stop employed. The operation must, of course, be repeated for any other sized stop that is inserted between the lenses.

It would be of great advantage to photographers generally, if, in the description of experiments, etc., the above *intensity ratio* were always recorded, as it is the only real standard of comparison between the rapidities of different lenses.

The *back focus* of double-combination lenses, as, for instance, of a portrait lens, depends upon the separation or interval between the two combinations; it is, therefore, a variable quantity, and cannot be taken as a measure

of comparison between lenses of different construction. The true standard of comparison for double or multiple combination lenses is what is termed the *equivalent focus*, or the *equivalent focal length*, viz., that quantity, or length, which is equal to the *solar focus* (or the focus for parallel rays) of a thin single lens, such as a spectacle eye lens. Hence the name equivalent focus.

Since, however, the size of an image produced by any lens is always in exact proportion to its equivalent focus, the latter can readily be determined, if the former is known and *vice versâ*. To judge, then, of the comparative focal lengths of any two lenses we have only to place them side by side and to compare the size of their respective images, both pointing to the same object. For example :

A spectacle eye lens has a solar focus of exactly 10 inches, and the size of image produced by it of some distant object measures 4 inches in height; the same object focussed upon with a portrait lens measures 8 inches on the screen. Required the equivalent focus of the portrait lens. Then, by simple proportion, as the size of image of the one is to that of the other, so also are their foci, or as 4 : 8 : : 10 : 20 inches, the *equivalent focus* of the portrait lens in question.

The above method affords a ready means of comparing

the relative focal lengths of different lenses when placed side by side; but to arrive at the absolute equivalent focus of a given combination is somewhat more troublesome, and involves the possession of a single lens, the solar focus of which has to be measured with great care.

There is, however, a readier mode for ascertaining the absolute equivalent focus of any combination lens, and this, with sufficient accuracy for almost every purpose; besides which, no adjunct is required, other than that in the possession of every photographer. It depends upon a law in optics; namely, that when the size of the image produced by a lens is exactly equal to that of the object, then the distance between the object and the focussing screen measures exactly four times the equivalent focus of the lens.

To find the equivalent focus of a given lens, proceed as follows: Take a flat piece of wood, as a drawing-board, with a piece of paper stretched upon it, place it before the camera, and adjust it at right angles to the lens in two planes, as is customary for copying pictures or maps. Draw two lines at right angles to each other upon the paper, and see that the point of intersection coincides with the axis of the lens and the centre of the focussing screen. On each side of the centre of one of the lines, measure and mark off with a pair of compasses a certain distance, equal

to about one-fourth of the base line of the focussing screen. Now proceed, as in copying, for equal size or scale, *i. e.*, adjust the distance between lens and object, and lens and screen, until the image of the mapped line on the screen, *when sharply defined*, is exactly equal in length to that on the paper. The pair of compasses already made use of answers the purpose. Now remove the lens, and carefully measure the distance between the paper and the focussing screen; and one *fourth* of this distance is the *equivalent focus* of the lens in question. The approximate *optical centre* of the lens can be determined at one and the same operation. For this purpose, replace the lens, without altering the arrangement, and make a mark upon the mounting or tube exactly equal to *one-half* the distance between the paper and focussing screen, measuring from the former. This point marked upon the lens-tube indicates the optical centre of the combination, and is, in fact, the zero from which to calculate or to measure the distance of the object, and the focussing screen, either for enlarging or reducing to a given scale.

To find the exact positions of the object and the focussing screen, both measured from the optical centre of the lens, for a given enlargement, add 1 to the number of times you wish to enlarge, which, multiplied by the focal length

of the lens, gives the position of the focussing screen, or indicates the required length of the camera; and this length divided by the number of times of enlargement gives the position of the object that is to be enlarged. Thus: required to enlarge a 5×4 negative four times (*i. e.*, to 20×16 inches), with an 8 inch equivalent focus lens; then to $4 + 1$, equals 5, multiplied by 8, equals 40 inches, or the length of the camera or position of the focussing screen; and 40 divided by 4 equals 10 inches, the distance at which to place the negative from the optical centre of the lens. For *reducing*, the positions of object and focussing screen are as follows—add 1 to the number of times you wish to reduce, and multiply by the equivalent focus of the lens, the product gives the distance of the object from the lens; and this, divided by the number of times you wish to reduce, indicates the position of the focussing screen, or the length of the camera. In the above example we have only to change the place of object for the screen, and *vice versâ*, when the positions are correct for reducing to $\frac{1}{4}$ scale.

In copying transparencies, carefully guard against any other but *parallel* rays being made use of for the formation of the image. To effect this, place a parallel box of light wood or paper projecting a considerable distance in front of the transparency; the box should be blackened

inside, or, better still, lined with velvet, or provided with several diaphragms with openings of the same size as the transparency.

Always endeavor to shade the lens as much as possible, *i. e.*, keep from it all extraneous light not actually used for the formation of the image, and the resulting picture will have its brilliancy proportionally augmented. This remark applies more especially to double or multiple combination lenses.

The glasses composing a lens should be free from veins, striæ, etc., and the several surfaces should be well polished by the optician; any remaining dull or grey appearance after careful wiping indicates defective polish. The presence of a few air bubbles *does not in any way affect the performance* of a lens; but, unfortunately, everyone can see these, whereas other defects much more serious can only be detected by a practiced eye. The more limpid or colorless the glass, the better the lens.

The fewer the number of reflecting surfaces, other things being equal, the greater the brilliancy of the resulting picture.

The smaller the diameters of double combination lenses, and the nearer that they are placed together, other things being equal, the greater the freedom from flare.

Keep the lenses as much as possible in a *dry* atmosphere, and guard against sudden changes of temperature, otherwise some kinds of glass are liable to tarnish, or what is technically termed to "sweat." Whenever any moisture becomes visible upon any surface, at once remove it by wiping with a *soft* cambric or old silk handkerchief; otherwise resort to wiping *only* when particles of dust adhere so firmly to the glass that they cannot be removed with a camel's hair-brush. Never attempt to polish the lenses with any kind of powder whatever.

THE END.

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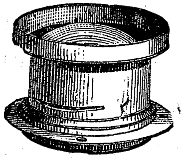

These Lenses are absolutely rectilinear; they embrace an angle of fully 100 degrees, and are the most rapid *wide-angle* lenses made. We recommend them for use with the foregoing outfits.

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No. 1,	¾ diam. of lens,	4 x 4 in. plates,	3 in.	equiv.	focus,	each,	$25 00
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No. 3,	1 " "	4½ x 7½ "	4¼	"	"	"	25 00
No. 4,	1 " "	5 x 8 "	5¼	"	"	"	25 00

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Are entirely different in many particulars from any other lenses in the market. They are 6 inches focus and 1¼ inch in diameter, and of course can be obtained in matched pairs, if desired. By using a set of diaphragms provided they are adapted for making 5 x 8 views.

A novel and ingenious instantaneous drop is also provided, passing through the brasswork, on the same principle as a central stop, by which *absolutely instantaneous views*, 4 x 5 inches, may be made, sharp all over to the very edges, without being diaphragmed down.

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We can also furnish the following, either single or in pairs:

The Lenses are especially designed for Stereoscopic Photography, and are so constructed that they will work well for interiors or exteriors.

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Diameter of Lenses, 1½ inch; focal length, 3½ inches.

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They are supplied with six Waterhouse diaphragms in morocco case.

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This apparatus is manufactured in New York City under our immediate personal supervision; and, as we employ only highly skilled workmen, and use nothing but the choicest selected materials, we do not hesitate to assert that the products of our factory are unequaled in durability, excellence of workmanship, and style of finish. This fact is now freely conceded not only in this country but throughout Great Britain, France, Germany, Australia, and South America.

Quality being considered, our prices are moderate, as the same grade of apparatus cannot be supplied for less price.

OUTFIT No. 201, complete, price $26 50,

CONSISTS OF

A Mahogany Polished Camera for taking pictures 4 x 4 inches, with *Folding Bellows Body*, single swing, hinged bed, and brass guides. It has a shifting front for adjusting the sky and foreground, also—

1 Patent Double Dry Plate Holder.
1 Taylor Folding Tripod.
1 Canvas Case to contain Camera and Holder.

OUTFIT No. 202, complete, price $27 00,

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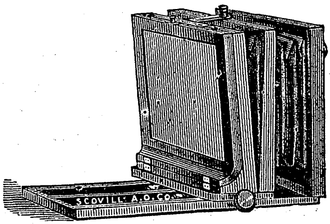
A Folding Mahogany Camera for taking 4 x 5 pictures, same style as 201 Camera, also—

1 Patent Double Dry Plate Holder.
1 Canvas Carrying Case.
1 Taylor Folding Tripod.

OUTFIT No. 203, complete, price $41 00,

CONSISTS OF

A Folding Mahogany Camera, fully described in the American Optical



Company's Catalogue, and well known as the '76 Camera (see illustration.) It is adapted for taking 5 x 8 pictures, and also for stereoscopic views—together with

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Cameras in Outfits 202 and 203 have shifting fronts, and are equal in style and finish to the best of the American Optical Company's make.

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For a choice of lenses suitable to these outfits, see next page.

For a choice of lenses suitable to these outfits, see next page.